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Survey of potential den sites for Luaner *Dasyurus viverrinus* in Dja Dja Wurrung country, central Victoria

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Abstract

An ecological feasibility assessment examined two sites in detail for reintroduction of a spirit species (totem), known as Yung or Luaner (Eastern Quoll *Dasyurus viverrinus*), back on to Dja Dja Wurrung country (Central Victoria). Woolshed Swamp and Mt Egbert Reserves both had habitat and food resources, and, with extensions, enough area to support a viable Luaner population (> 50 adults). The availability of terrestrial den sites became the potentially limiting factor.

A methodology was developed classifying five types of potential den sites into two classes: *robust* (large trees, large on-ground logs, ground cavities) and *temporary* (smaller logs, bushes). Transects (100 m by 50 m, n = 38) revealed all woodland types had robust den sites ≥ 20/ha (range: 20.9–34.6), but there were fewer elsewhere. Human perception does not equate to Luaner usage of all these sites *per se*. However, it was concluded that the availability of den sites was not a limiting ecological factor at either site. (*The Victorian Naturalist* 139(2), 2022, 36–43)

Keywords: Eastern Quoll, Yung, spirit (totem), Woolshed Swamp, Mt Egbert

Introduction

The Luaner/Eastern Quoll *Dasyurus viverrinus* is a cat-sized, nocturnal, carnivorous marsupial. It eats primarily insects but small-medium sized vertebrates are also taken across its various habitats, ranging from dry eucalypt forest, woodlands and heathlands to grasslands.

Howitt (1904) recognised the Luaner as a totem, hereafter *spirit*, in Wotjobulak country. (For nomenclature see Abbott 2013). It was also a spirit in Dja Dja Wurrung country, where it was called Yung. That name was variously anglicised but is now recognised as Yung. The species disappeared from Dja Dja Wurrung country and most of Victoria around the turn of the 20th century, possibly due to an epidemic. The last Victorian records were made around Melbourne in the 1950s (Fleay 1932; Menkhorst 1995).

The Luaner is an endangered meso-predator, extinct on the mainland since the 1950s but still extant in Tasmania, where its previous 'Secure' status has been changed to 'Threatened' (Menkhorst 1995; Fancourt *et al.* 2015; Burbidge and Woinarski 2016). There are two semi-wild populations on the mainland, protected within predator-proof fences at Mt Rothwell, Victoria, and Goorooyarroo–Mulligans Flat, Australian Capital Territory (ACT).

The Dja Dja Wurrung seek to reintroduce the Luaner back on to country. It is integral to both their caring for country and implementing their *Country Plan 2014–2034* (Dja Dja Wurrung Aboriginal Clans Corporation [DDWACC] 2014). Returning spirits back on to country is also a priority for Traditional Owners under the Victorian Biodiversity Strategy (Department of Environment, Land, Water and Planning [DELWP] 2017) and supplementary papers (DELWP 2021). The Dja Dja Wurrung commissioned an ecological feasibility study for reintroduction of the Luaner, focused on two culturally significant sites over which they had achieved land rights: Woolshed Swamp and Mt Egbert reserves, respectively 4 km and 20 km south of Boort in Yung Balag Djandak. Buckrabanyule, which is similar in character to Mt Egbert and co-managed by DDWACC with Bush Heritage, was also inspected but not in detail.

The full ecological assessment of these sites (Mansergh 2020) found in summary that both supported sufficient areas of habitat and potential food resources known to be used by

Luaners, but the current size of both reserves was too small to support a viable population. (The total area of Woolshed Swamp is 475 ha, but habitat is reduced to 255 ha when it is full of water; Mt Egbert is 330 ha in area.) Fortunately, Mt Egbert now abuts the 1207 ha Bush Heritage property of Nardoo Hills where management is sympathetic to wildlife and Dja Dja Wurrung cultural heritage (https://www.bushheritage.org.au/places-we-protect/victoria/nardoo-hills). An approximately 200 ha eastward extension of Woolshed Swamp to the rail easement is possible through acquisition of private land. Thus, feasible extensions with good area-to-perimeter ratios could be expected to increase the size of Woolshed Swamp to 655 ha, with a Luaner population estimate of 57–135; and Mt Egbert to 951 ha, with a Luaner population estimate of 114–190 (Mansergh 2020). The availability of den sites required by the species was potentially the key limiting factor. The purpose of this paper is to show how availability was assessed.

Godsell's 1983 examination of wild populations in Tasmania provides the most comprehensive work on the species to date. Radio-tracked Luaners enabled the location and classification of actively used den sites (n = 85). In favoured areas (woodland gullies), den sites occurred at densities of 1.2/ha but were much less dense in pasture (0.3/ha). Entrances to dens were located in logs and tree roots (22.3 %), in blackberries or thickets (37.6%) and where there was no cover (11.7%). Individual Luaners use multiple den sites (mean = 5 for females) and frequently travel 500 m to foraging areas. Subterranean dens are favoured (c. 70%), but Luaners are not restricted to them. Fallen trees, rock and earth piles are also used and Fleay (1932, 1935) found that Luaners use rabbit warrens.

Methods

In this study, a methodology was developed to assess the availability of potential den sites. Although literature is available on arboreal mammal surveys for tree hollows, there is a surprising dearth of material on surveys for potential den sites for terrestrial mammals. The following methodology was adopted. Data (maps) on the Ecological Vegetation Communities (EVCs) of the sites were extracted from DELWP *NatureKit* (accessed April 2020). The objective was not to maximise the potential den site count, but rather to get a conservative count that would provide a benchmark against the density observed by Godsell (1983). Thus, a maximum count of 3 was allowed under mature trees (canopy = 10 m diam.) and a maximum of three per circular area of 10 m diam. in rocky outcrops. Other potential sites, such as clumped branches and debris < 1 m in diam., were not counted.

Following on from Godsell (1983), potential den sites for the Luaner were categorised as the following types: (a) large mature trees ≥ 0.5 m diameter at breast height (dbh) with root/branch debris at base; (b) fallen tree/log ≥ 0.3 m diam. and ≥ 2 m in length; (c) ex-burrows or rock crevices having depth ≥ 0.3 m; (d) large branches < 0.3 m and > 0.1 m diam. and ≥ 2 m in length; and (e) shrubs ≥ 1 m diam. of canopy cover. Types a, b, and c were classed as robust, being more permanent with existing hollows and crevices that might require minimal excavation, and types d and e as temporary.

Two areas (reserves) were examined. However, the central geomorphological feature of each reserve was not surveyed, for different reasons. At Woolshed Swamp, the central swamp (c. 200 ha) was subject to inundation and was excluded from the survey (Fig. 1), whilst at Mt Egbert the central feature was a granite intrusion forming a rocky outcrop (c. 200 ha) with almost uncountable potential den sites (Figs 2 and 3). Survey sites were selected where rocky outcrops were ≤ 10% of the area surveyed. Potential den sites (by type) were counted 25 m either side of 100 m transects (= 0.5 ha), across the various vegetation types at each site in March–June 2020. Six transects were undertaken in each EVC at both Woolshed Swamp and Mt Egbert. At Mt Egbert, data were recorded using existing EVCs—Grassy Woodland, Hilltop Herb-rich Woodland, and Sandstone Ridge Shrubland, but at Woolshed Swamp (a more disturbed site) the two woodland EVCs were treated as one (Woodland) but divided into: Woodland with an intact canopy or depleted canopy. These types comprised four habitat structures: (a) mature woodland (Grassy Woodland and Plains Woodland EVCs); (b) depleted canopy wood-

Fig. 1. Aerial photograph (2019) of Woolshed Swamp. Numbers locate transects undertaken for potential Luaner den sites. Structural habitat type: mature woodland (# shown in red); depleted woodland canopy (# shown in white), regenerating River Red Gum (# shown in yellow) and grassland pasture (# shown in blue).

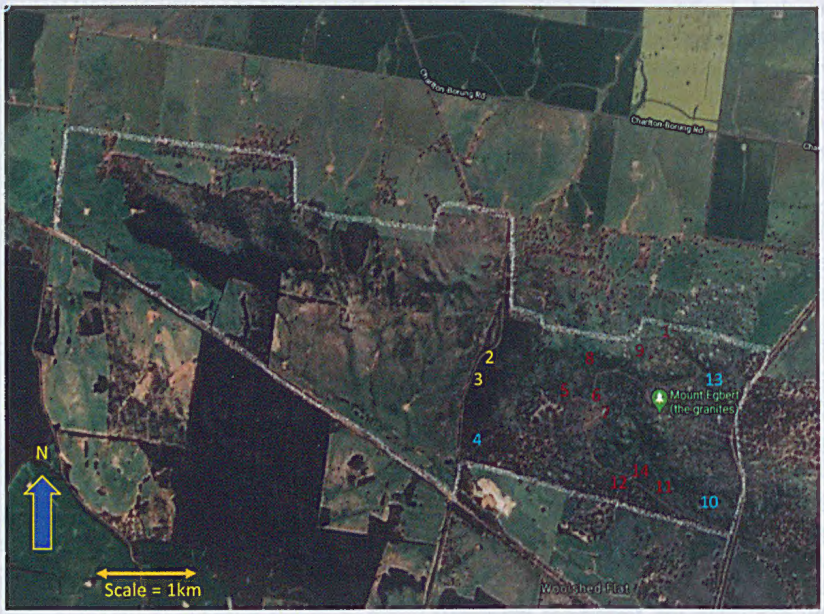

Fig. 2. Potential Luaner reintroduction sites at Mt Egbert and two properties to the west showing sites of transects: red = Hilltop Herb-rich Woodlands; blue = Grassy Woodlands; yellow = Sandstone Shrubland.

Fig. 3. Southward view from Mt Egbert. Granite rocky outcrops are extensive at high and mid elevations in the reserve, providing abundant potential den sites for Luaner and other species. Transects were not conducted across expanses of rocky outcrop. Rocky outcrop was limited to 10% of area of woodland transects. Photo M Nash.

land and grassland (6–12 trees/ha) (Grassy Woodland and Plains Woodland EVCs); (c) regenerating River Red Gum (thickets 60 mm dbh to more open groundcover trees at ≥ 100 mm dbh) (Lignum Swamp Woodland EVC); and (d) grassland pasture < 0.5 mature trees/ha.

Results

In total, 38 transects were completed. Six transects were in each of the four structural habitats at Woolshed Swamp (n = 24) (Table 1). At Mt Egbert (n = 14), Hilltop Herb-rich Woodland was the most extensive vegetation with 10 transects, and Grassy Woodland and Sandstone Ridge Shrubland each had two transects (Table 2). Transect locations are shown in Figs 1 and 2. Transects were restricted to within existing reserves except for one at Woolshed Swamp that was on private land (Fig. 1, #1). Although no formal transects were undertaken within the proposed extensions, den sites were observed there. Photographs of types of potential den sites are shown in Figs 3–7. An estimated 25% of trees and logs in types a and b supported hollows > 100 mm diam., such as those resulting from fire. These were not specifically counted but represent 'no-excavation' potential sites (Figs 4–6).

Using the area of woodland and the lowest density estimate for robust den sites in each type of woodland, there were > 3000 potential den sites at Woolshed Swamp and > 9000 at Mt Egbert (Tables 1 and 2). Presuming robust classes (a, b, and c) are more favourable sites for Luaners to invest in 'excavation', the mature woodland and depleted canopy woodlands at Woolshed Swamp (≥ 20/ha), and woodlands at Mt Egbert (≥ 33/ha) support abundant potential den sites. These sites are well distributed across the reserves (Figs 1 and 2). Other habitats at Woolshed Swamp—regenerating River Red Gum (4.3/ha) and grassland pasture (6.7/ha)—support these classes of den sites at much lower density, as does Sandstone Ridge Shrubland (9/ha) at Mt Egbert. However, these vegetation types generally had abundant potential temporary den sites (shrubs and smaller logs) (Tables 1 and 2).

Table 1. The density of potential Luaner den sites across four structural vegetation types at Woolshed Reserve. Den sites deemed of higher quality/permanence are in blue. +Estimated from Endersby (2013) updated EVC map—open water (no trees) = 200 ha. Sum of approx. area for woodland = 155.0 ha. *Site # 23 had small section of quarry = 8 rock crevices/ex-burrows.

Habitat structure	No. of transects	Approx. area (ha)+	Mean density of class of den site / ha						
			a	b	c	a + b + c	d	e	Total
Mature woodland	6.0	110.0	11.3	14.0	0.0	25.3	22.3	16.6	64.2
Depleted woodland canopy	6.0	45.0	11.0	9.7	0.3	21.0	14.0	7.3	42.3
Regenerating River Red Gum	6.0	150.0	3.0	1.3	0.0	4.3	5.0	16.0	25.3
Grassland pasture	6.0	180.0	0.7	3.3	2.7*	6.7	4.0	23.0	33.7

Table 2. The density of potential Luaner den sites across three ecological vegetation communities at Mt Egbert Reserve. Den sites deemed of higher quality/permanence are in blue. +Estimated from Endersby (2013) updated EVC map—open water (no trees) = 200.0 ha. Sum of approx. area for woodland = 285.0 ha.

Habitat structure	No. of transects	Approx. area (ha)+	Mean density/ha/type of den site						
			a	b	c	a + b + c	d	e	Total
Grassy woodland	2.0	55.0	14.0	19.0	0.0	33.0	19.0	10.0	62.0
Hilltop Herb-rich Woodland	10.0	230.0	10.0	17.4	7.2	34.6	12.0	6.4	53.0
Sandstone Ridge Shrubland	2.0	45.0	1.0	8.0	0.0	9.0	16.0	28.0	53.0

Fig. 4. Depleted woodland site at northwest corner of Woolshed Swamp (transect #7 in Fig. 1). Blue squares = robust potential sites; red squares = temporary potential sites. Note only three robust sites were recorded for analysis at this site, but the over-abundance of potential sites is evident.

Fig. 5. Woolshed Swamp. Blue squares = robust potential den sites; red squares = temporary potential den sites. Two robust den sites and one of three temporary den sites were counted in the mid foreground; there were two robust den sites in the background (see text).

Given the definition of the classes of den sites, the availability of potential den sites at Woolshed Swamp and Mt Egbert appears to be very abundant (Tables 1 and 2). The unsurveyed (inundated) area at Woolshed would contain few, if any, additional potential den sites. However, potential den sites would be very abundant in the unsurveyed rocky outcrop areas at Mt Egbert.

Discussion

Although studies exist for surveys of arboreal mammal den sites (tree hollows), no previous studies were located of surveys for terrestrial

Fig. 6. Mt Egbert Hilltop Herb-rich Woodlands: four robust den sites (blue squares—centre and a rocky outcrop in the background). The centre square shows a fire-enhanced hollow log > 0.5 m dia. Temporary den sites (red square) were not counted at this site (see text).

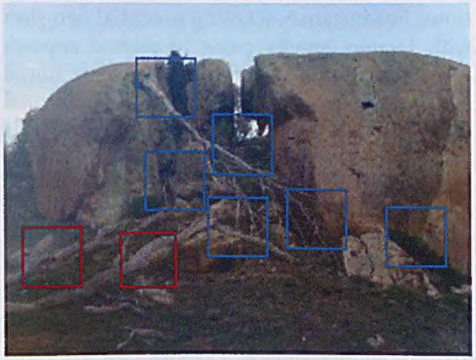

Fig. 7. Granite tor on transect #5 (Fig. 2) in Hilltop Herb-rich Woodland. Blue squares = robust potential sites; red squares = temporary potential sites. Only three of six robust den sites were recorded here (see text).

studies were located of surveys for terrestrial mammal den sites where species were not already present (i.e. for reintroduction sites). In assessing reintroduction feasibility at Woolshed Swamp and Mt Egbert, what is known of the Luaner's ecological requirements must be considered in relation to den site abundance.

In Tasmania, over an area of 355 ha (205 ha pasture, 125 ha forest, and 25 ha forested gullies), Godsell (1983) found the density of utilised den sites (n = 85) to be: 0.04/ha in pasture, 0.37/ha in treed areas and 1.2/ha in treed gullies (overall mean 0.24/ha). Females used an average of about five den sites, which could be accessed by different animals on consecutive nights. Males had larger home ranges and a single male used 12 den sites. Luaners were found to be mostly solitary animals—nest sharing was uncommon but not unknown, and the home ranges of both genders overlapped extensively. Upon death or vacancy, den sites were utilised by the next generation. Male Luaners changed their den sites frequently, if not nightly, as did females, except during lactation and nursing (Godsell 1983).

Godsell also found about 70% of den sites were subterranean and yet Luaners are poor 'diggers', even in food provision, hence they readily use old rabbit burrows and existing rock crevices (Fleay 1932, 1935). The time taken to modify any site by scratching and digging is not known. At Mt Rothwell, Victoria, where a viable semi-wild population of Luaners (50 to ≥ 100 animals) has been husbanded since 2004, no special effort was made by the management of that time to excavate den sites either when Luaners were introduced or subsequently (see www.mtrothwell.com.au; Annette Rypalski, pers. comm. 2020). Luaners made relevant adjustments through excavations and grass linings, turning the existing potential into actual den sites. Woolshed Swamp, and particularly Mt Egbert, have many environmental similarities to Mt Rothwell, such as their EVCs and mean annual rainfall (Mansergh 2020). A density of 20 Luaner/km^2, as found at Mt Rothwell, was used for assessment of these sites by Mansergh (2020). Presumed usage of five den sites by each animal leads to a requirement of one den site per hectare for each animal. Density of perceived robust potential den sites at both localities exceeds this figure by 20 times (Tables 1 and 2).

Luaners may travel over 500 m from den site to forage areas (Godsell 1982, 1983), making all areas in the reserves and proposed extensions available. Indeed, a favoured habitat in Tasmania is the forest–woodland interface with pasture or grasslands (Dean Heinze, pers. comm. 2020; Godsell 1983). These ecotones are widespread across both potential reintroduction sites (Figs 1 and 2). From the experience at Mulligans Flat, ACT, Wilson *et al.* (2020) provide important tactics for Luaner reintroduc-

tions. For instance, scenting potential den sites with Luaner 'smells' prior to release appears to decrease release trauma and increase initial site area fidelity. Reestablishment of Traditional Owner mosaic patch burning of grasslands has been recommended at the sites to promote Luaner food resources. This activity should consider potential and, in future, actual den sites (Mansergh 2020).

The apparent superabundance of potential den sites for the Luaner also allows for the possibility of reintroducing other species. Reintroduction of the Rufous Bettong *Aepyprymnus rufescens* has been recommended at both sites for its 'eco-engineering' potential (improvement in soil health, fungi dispersal and water penetration) (Davies *et al.* 2019). The Rufous Bettong could utilise the many sites where tussock grasses are common (Wallis *et al.* 1989; Southwell 1987; Mansergh 2020). Prior to colonisation, there were possibly four species of bettong in Dja Dja Wurrung country, but all are now extinct in Victoria—as is their ecological function (Woinarski *et al.* 2015; Menkhorst 1995). Dja Daj Wurrung country was an important part of the Victorian range of the Rufous Bettong, but its eco-engineering function has been absent from this country for a century. Restoring ecological health and an extra food resource for the Luaner must be considered.

The geomorphology of these sites (large swamp and infertile rocky granite outcrop) protected them from the land grab of colonial Victoria, and the Land Conservation Council (LCC) protected them as reserves in the 1980s (LCC 1978, 1983). Subsequently, basic neglect and fires (Mt Egbert has had three fires in the last 50 years) has left an environment rich in fallen trees and hollow logs (e.g. River Red Gum, Black Butt and Grey Box—all highly durable timbers; Figs 4–6) and to a lesser extent mature trees (dbh > 1.2 m at Woolshed Swamp). For potential Luaner den sites, this neglect has had some benign consequences. Another form of neglect is more invidious, specifically lack of environmental flows to Woolshed Swamp has increased the salinity risk. The West Waranga Channel cuts off 80% of its natural catchment (Solum 2013; Endersby 2013). Two nationally threatened Woodland EVCs are basically doomed without some long-term water security. This swamp gets less water less often and thus the habitat for four threatened wetland birds and 14 Dja Dja Wurrung wetland spirit species is diminished (Solum 2013; Endersby 2013).

Conclusion

At both sites there is an abundance of potential den sites (of different human-perceived quality) that will allow reintroduced Luaner to select sites that best suit them. However, in the absence of environmental flows, Woolshed Swamp is a less attractive site in the longer term. Potential den sites are well distributed across the reserves, allowing access to all foraging areas. There are more than enough potential and 'permanent' den sites to support > 100 Luaners, and, indeed, other species. Although not examined in detail, a similar situation at Buckrabanyule is highly probable. Thus, it is concluded that the availability of several types of den site is not a limiting factor for Luaner reintroduction at these locations.

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Defensive behaviours, inclination to bite and envenomation in the Little Whip Snake *Suta flagellum* (Elapidae)

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Abstract
The defensive behaviours of the Little Whip Snake *Suta flagellum* in the field are described and the frequency of these behaviours is quantified. Males employed the threat display more often than females whereas females attempted to bite more often than males; a significant association was found between defensive behaviour and sex. The threat display was the most frequently employed response (52%) but attempts to flee were the most frequently employed first response (91%), followed by the threat display (79%). Juvenile snakes exhibited body coiling significantly more often than adults. *Suta flagellum* lacks a defensive strike and so bites defensively in the same manner as when feeding. The symptoms of single bites from a juvenile *S. flagellum* and an adult Dwyer's Snake *S. dwyeri* were localised and very mild but both resulted in delayed allergic reactions. (*The Victorian Naturalist* **139**(2), 2022, 43–52)

Keywords: *Suta flagellum*, *Suta dwyeri*, defensive behaviour, threat, bite

Introduction
Members of the genus *Suta* are venomous but typically regarded as harmless, owing to their small size (total length < 0.6 m) and reluctance to bite (Kinghorn 1967; Gow 1989; Wilson and Knowles 1988; Coventry and Robertson 1991; Ehmann 1992; Cogger 2014; Mirtschin *et al.* 2017). *Suta* spp. exhibit multiple, sometimes erratic, defensive behaviours in response to threats, of which body coiling and sudden thrashing are displays common to most species (Johnson 1975; Wilson and Swan 2010). Bites from *Suta* spp. are generally regarded as 'medically insignificant' (Mirtschin *et al.* 2017) although, being secretive nocturnal snakes, this could be a reflection of the lack of documented envenoming. Recent studies have focused

mainly on the toxicology and, to a lesser extent, the pharmacology of small elapid snake venoms but have revealed varying pharmacological activity producing mild to moderate effects (Blomberg 1997; Mirtschin *et al.* 2017; Pycroft *et al.* 2012; Jackson *et al.* 2013). Bites from *Suta* species have occurred to individuals in the field and also to herpetoculturalists but are seldom reported, presumably because the symptoms were mild and required no medical treatment. Some authors have, however, commented that bites from *Suta* species should be treated with caution and that bites from large specimens could result in uncomfortable symptoms that may require treatment (e.g. Gow 1989; Wilson and Swan 2010; Robertson and Coventry 2019).

The focus of this work is the Little Whip Snake *S. flagellum*, a small elapid species (total length < 0.45 m) that is confined mainly to south-eastern Australia, where it is typically located beneath stones during the day (Wilson and Swan 2010; Cogger 2014; Robertson and Coventry 2019). In the species' description, McCoy (1878: 8) states that a bite from an *S. flagellum* is 'no more injurious than the sting of a bee, although its little poison fang and gland are on the usual plan of construction of the large dangerous species. The venom of *S. flagellum* was tested by Kellaway (1934) on several species of small mammals. Kellaway concluded that the snake was 'innocuous' and not dangerous to humans because of the small amount of venom injected, a statement that has been repeated in field guides for decades since. However, a recent adult fatality, apparently resulting from complications following a bite from an S. flagellum (Harrison 2007), has led some authors (e.g. Rowland and Eipper 2018) to regard bites from this species as 'potentially dangerous'.

In this paper, I present observations on the defensive behaviours, inclination to bite, and a single case of envenomation by *S. flagellum*. For comparison, I also document a single case of envenomation by a Dwyer's Snake *S. dwyeri*.

Methods

In the course of doing field work in grasslands north and west of Melbourne between 1990 and 1994, day-time searches for *S. flagellum* beneath ground cover were conducted and once located they were examined (see Turner 2019). The snake's reaction to being handled was noted in only the last two years of field work resulting in a sample of approximately 170 snakes. As multiple behaviours were typically observed, the order in which they occurred was recorded (i.e. first, second, third, etc.) along with the sex and size class (adult, sub-adult, juvenile; see Turner 2019) of individual snakes. However, in the analyses below, the sub-adult and juvenile size classes were merged owing to the small number of sub-adults in the sample. In addition, approximately 85 captive snakes were handled regularly by the author for the purposes of maintaining length and weight records and the cleaning of enclosures over the period 1983–1994. Most of these snakes were captive-bred juveniles, with approximately 15 adult snakes and with typically no more than 10 snakes being maintained at any one time. Most captive snakes became accustomed to handling, to the extent that all of the defensive behaviours (described below) ceased, but direct contact with the head was always avoided. Contingency tables were used to test associations between variables, with the χ^2 statistic computed (using Yates's correction for continuity) and, also, the odds ratio was computed for significant associations. A three-way log-linear analysis was used to determine associations between defensive behaviour, sex and size.

Observations

Defensive behaviour

The defensive behaviours of *S. flagellum* have been described by various authors (Jenkins and Bartell 1980; Fyfe and Booth 1984; Turner 1984) and consist of the following (in no particular order):

(i) threat display (Fig. 1): the snake's head is raised above the ground, the body is inflated, there is frequent tongue flicker and the snake thrashes about in wide arcs (in 'whip-like' fashion) often accompanied by audible hissing;

(ii) body coiling (Fig. 2): the snake's body is dorso-ventrally flattened and rigidly coiled, sometimes knotted, often resembling a shallow cone with its head either at the apex or amongst the coils;

(iii) odour emission (also referred to as 'musking'): the snake produces an unpleasant

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Fig. 1. Threat display in the Little Whip Snake *Suta flagellum*, with the head and anterior body raised clear of the ground and the body inflated; each sudden thrashing movement was accompanied by hissing.

Fig. 2. Body coiling behaviour in the Little Whip Snake *Suta flagellum*, with rigid coils and the head (partly) concealed at the apex.

odour, presumably from the post-anal glands, described as being 'a sharp ant-like' odour (Rawlinson 1965);

(iv) biting: snakes would attempt to bite during handling and also when objects were placed near their head; and

(v) escape: snakes would move away from perceived danger, typically seeking nearby ground cover.

Approximately half of all *S. flagellum* exhibited the threat display for which the species is well-known (52%; Table 1) and for most of these (79%), it was their first response. Only 38% of snakes attempted to escape; for most of these snakes (91%) it was also their first response (Table 1), followed by the threat display (79%). Approximately one-third of all snakes attempted to bite and also produced an odour, while body coiling was the least frequently observed behaviour (16%). It is notable that biting was employed least as a first response (12.5%) and instead was employed as second or third line of defence (combined 77.5%); a similar pattern was seen for body coiling behaviour.

Some defensive behaviours were displayed more by one sex than the other. The threat display was exhibited significantly more by males than by females (2×2 contingency table; χ^2 = 5.10, 1df, P = 0.024); based on the odds ratio, males were 2.3 times more likely to exhibit the threat display compared to females. Conversely, females tended to bite more than males (2×2 contingency table; χ^2 = 4.02, 1df, P = 0.045); based on the odds ratio females were 2.1 times more likely to bite compared to males. Other defensive behaviours did not differ significantly in their frequency of display between males and females ($P > 0.3$) for all. By restricting the data analysis to just first responses, and the behavioural categories to threat display, biting and escape, the assumptions of log-linear analysis were met (with n = 133). The results of this analysis indicated the highest order interaction (sex × size × behaviour; χ^2 = 17.54, 7df, P = 0.014) and the two-way interaction between sex and behaviour with the effect of size removed (χ^2 = 12.96, 4df, P = 0.011) were statistically significant, and consequently the interaction between sex and behaviour was highly significant (χ^2 = 12.28, 2df, P = 0.002). These results lend support to the contingency table analysis.

When examined with respect to size class (adults vs juveniles), the only statistically significant difference in the frequency of defensive behaviours was body coiling, which was exhibited significantly more by juvenile than by adult snakes (2×2 contingency table; χ^2 = 11.57, 1df, P = 0.0007); based on the odds ratio, juveniles were 4.4 times more likely to exhibit body coiling compared to adults. Body coiling was

Fig. 3. Feeding behaviour in the Little Whip Snake *Suta flagellum*, in which two body coils are applied to an adult Tussock Skink *Pseudemoia pagenstecheri*.

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usually elicited by a tactile stimulus such as prodding or handling and was maintained for up to 20 minutes.

Biting action

Many large elapid snakes possess a defensive bite or strike that is often preceded by threat displays such as dorso-ventral flattening or lateral compression of the body, hissing, mouth gaping, the raising of the head and anterior body clear of the ground and an S-formation of the neck and anterior body (Gillam 1979; Shine 1991; Greer 1997; Whitaker *et al.* 2000). While most (all?) *Suta* spp. have threat displays involving some of these behaviours, none has been reported as possessing a defensive strike as such (see comments for *S. dwyeri* in Johnson 1975). In *S. flagellum*, once the defensive displays ceased and snakes were free-handled, the lack of a defensive strike gave the false impression of passivity, but this was often when snakes were inclined to bite.

Observations were made of the way in which *S. flagellum* subdued live prey. Complete observations of feeding were made of both adult (n = 6) and juvenile (n = 5) snakes on a total of 13 occasions. Snakes slowly approached their prey (skinks) with frequent tongue-flicker and, once the tongue had made contact with part of their prey (or nearly so), the snake would either: (i) make a short (< 10 mm), quick, lunge directed at its prey, or, (ii) continue moving toward its prey and then, without haste, open its mouth wide, ease its jaws over the prey and clamp-down. Once bitten, the prey was held firmly. Both juveniles and adults were often observed to use their neck and anterior body to help secure struggling prey (Fig. 3), applying usually between one and three coils around it. Prey was sometimes released once it was completely immobilised or dead, but more usually the bite was maintained at the original site and the snake then proceeded to 'step' each front-fang along the body of the skink towards its head and, once reached, commenced swallowing. All of these behaviours are consistent with the species preying on sleeping (diurnal) skinks at night, wherein the snake presumably relies entirely on scent to locate prey, bite it at close range, and then secure and retain the prey lest it escape.

Observations of *S. flagellum*, both in the field and in captivity, indicate that this species bites defensively in the same manner that it feeds (n ≈ 60). On being bitten (described below), and also in many near-misses, the lead-up to the bite was the same as it was for feeding: there was frequent tongue-flicker followed by either a short, quick lunge, or else the jaws were rather casually, and without haste, eased over the intended bite site. The slowness of the latter

Fig. 4. Biting behaviour in the Little Whip Snake *Suta flagellum*, in which a body coil is applied to the object (a pencil).

biting action led to all such biting attempts being avoided in the field. When small objects, such as a pencil, were placed near the snakes' heads during handling (in both captivity and in the field), these were frequently bitten, with the bite being prolonged (5–10 seconds), and the neck and anterior body often coiled around the object in the same manner as when attempting to restrain prey (Fig. 4).

Envenomation

Since many *S. flagellum* were handled in the field during winter when conditions were cool, the risk of being bitten was minimal because snakes were relatively slow in their general movements and consequently no bites occurred. When placed in a holding bag or container, snakes would often bite at these objects, sometimes repeatedly. Most attempted bites (n ≈ 70) occurred on warm days when snakes were capable of more rapid movements and were, generally, more difficult to handle. The two instances of envenomation described below occurred as a result of snakes being carelessly (free-) handled. The author had had no previous snake bites (and none in the intervening period), was in good health, and at the time bites occurred was aged 20 and 26 years respectively. Both bites were on digits of the right hand. One bite was from a neonate *S. flagellum*, the other from an adult *S. dwyeri*, and no first aid was administered in either case. These cases are described in turn.

Neonate *S. flagellum*

This specimen (total length ≈ 120 mm) was moving slowly and unrestrained in the palm of my right hand and showing no signs of agitation when it was observed to slowly ease its jaws over the side of my middle finger (just below the knuckle) and then clamped down. The snake hung on for around 10 seconds, chewing alternately with the left and right sides of the maxilla before releasing its grip. Both fangs pierced the skin with puncture marks visible and spaced about 5 mm apart. There was no immediate sensation at the bite site apart from a slight sting.

After two hours there was localised swelling and stiffness of the muscles both above and below the knuckle. The stinging sensation was confined to a small region around the bite site. There was pain associated with flexing and straightening the finger. The knuckle and bite site were red in appearance. Twelve hours after the bite, some swelling and redness persisted around the bite site and it was sensitive and slightly sore to touch. Stiffness around the knuckle joint persisted, as did the pain associated with flexing and straightening the finger. There was slight pain extending almost up to the second finger joint and well below the knuckle. The puncture marks were still visible. Approximately 24 hours after the bite, most symptoms persisted though the pain had completely abated. There was still stiffness around the knuckle and it was difficult to straighten the finger. Two days after the bite, there was localised soreness but the stiffness had gone. Six days after the bite, puncture marks were still visible but all other symptoms had disappeared. Overnight, however, both puncture marks developed into small raised lumps, resembling mosquito bites, and were very itchy for the entire day. By the next day, the itchiness, swellings and all other symptoms had disappeared. There was no further recurrence of symptoms.

Adult *S. dwyeri*

This specimen (total length ≈ 300 mm) was quite warm and capable of rapid movement when handled, and bit the upper side of my right thumb (below the knuckle joint) and hung on for only 3 or 4 seconds. Both fangs pierced the skin and one caused a small amount of bleeding.

Local stinging around the bite site was evident immediately. Six hours later the thumb knuckle had stiffened and the skin around the bite site was sensitive to touch. There was slight localised pain around the bite site, which was red but not swollen. Puncture marks were clearly visible and were about 10 mm apart. In the hours that followed the pain remained localised and did not increase in intensity but there was stiffness around the knuckle. Two days after the bite the pain was gone but the skin remained sensitive to touch. The redness around the bite site had by this time disappeared and there was no swelling. In the days that followed, the sensitivity and soreness around the bite site completely abated and the puncture marks were no longer visible. Seven days after the bite, over-

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night, the puncture marks emerged as raised lumps and were very itchy, becoming red again through frequent scratching. By the following day the itchiness had abated but swellings were still present; these disappeared by the next day. There was no further recurrence of symptoms.

Consulting a physician several months after the second bite, I described the curious 'return' of both bite marks a week after envenomation and was informed they were the result of a delayed allergic reaction to the venom, of which persistent itchiness (urticaria) is a symptom (R de Bruin, pers. comm. 1996).

Discussion

The varied defensive behaviours of *S. flagellum* appear to target the multiple senses of potential predators. The threat display exhibited by *S. flagellum* had several components. Raising the head clear of the substrate is a behaviour recognised in many species as an attempt to give the appearance of being larger and draw attention to the head (Bustard 1969) and may also signal a willingness to strike, both of which constitute visual bluffs in *S. flagellum*. Thrashing about in a sudden and erratic fashion is probably aimed at startling or confusing a would-be predator (see Johnson 1970 and references therein; Humphries and Driver 1967) and in *S. flagellum* it was always in response to perceived movements; the associated hissing would likely enhance the effect. It is suggested by Johnson (1970) that the 'whipping' action displayed in small elapids may serve to distract attention away from the head. In *S. flagellum*, the head and tail simultaneously move as the body thrashes about. It is plausible that this action does not so much distracts attention from the head but, possibly, leads to confusion about the location of the head and tail. Body coiling behaviour resulted in the snake resembling an inanimate object, with its head protected and body rigid to the extent that it could be handled with impunity (see Fig. 2). It would seem that, apart from protecting the head, and potentially deceiving predators, this behaviour might also make the snake more difficult to grasp or swallow. It is different from the elaborate death-feigning behaviour displayed in some other snake species (see Gehlbach 1970). Odour emission typically occurred in conjunction with the threat display and/or body coiling behaviour and, again, may serve to enhance the effectiveness of both of these displays, particularly the latter, by rendering the snake distasteful to predators.

There are some obvious similarities between the defensive behaviours displayed by *S. flagellum* and its cogener *S. dwyeri*. Johnson (1975) described the defensive displays of a variety of snakes, including *S. dwyeri* (n = 9), using 15 descriptors for general behaviours and another six for the tendency to strike and bite. The descriptors, 'whipping action' and 'lunging-leaping', applied to *S. dwyeri* are probably similar, or equivalent to, the threat display exhibited by *S. flagellum*. Like *S. flagellum*, *S. dwyeri* will readily attempt to bite when handled but never strike. In addition, *S. dwyeri*'s defensive repertoire included (dorso-ventral) 'depression of the head and neck' and 'head hiding' in which the head is hidden beneath part of the body or buried in the substrate, but there is no mention of body coiling as displayed by *S. flagellum* (it is described as a separate behaviour, 'spiral coils above substrate', and was not observed in *S. dwyeri*; Johnson 1975). Two other behaviours were exhibited by one, but not the other, species: tail vibration (*S. dwyeri*) and odour emission (*S. flagellum*). Tail vibration or wriggling was observed in only a small number of *S. flagellum* in the field (n < 15) and occurred in individuals displaying body coiling. Whether it was a simple expression of anxiety or an attempt to divert attention away from the head (Greene 1973; Johnson 1975) is uncertain, but the almost complete lack of tail injuries observed in field specimens (see Turner 2019) suggests that this behaviour is not diversionary. It is evident that both *S. flagellum* and *S. dwyeri* have evolved a variety of defensive behaviours, some quite elaborate, and this may indicate that they are subject to multiple (rather than a single) predators. The predators of both species are unknown.

The greater tendency for female *S. flagellum* to bite and for males to employ the threat display may be related to differences in their physical strength. Male *S. flagellum* also employ threat-like displays when engaged in male-male combat but only occasionally bite one another in this context (Turner 1992). From handling adult snakes, it is evident that males tend to

be physically stronger and more agile than females, the latter generally being more heavily bodied. Fyfe and Booth (1984) also observed a greater tendency for female *S. flagellum* to bite, though this was not quantified. In addition, it was noted above that *S. flagellum* were generally more inclined to bite when handled on warmer days when they were capable of rapid movement. The greater tendency for juvenile snakes to exhibit coiling behaviour may be because their small size makes other defensive displays such as biting, threat and odour emission less effective against certain predators. Body coiling behaviour potentially involves a high risk of injury and/or predation because the snake remains exposed to predators while lying passively. The observations of *S. flagellum* biting and then coiling around objects placed close to their heads when agitated may represent an example of displacement behaviour, a behaviour that occurs when an animal experiences conflicting drives resulting in a behaviour which is inappropriate (Barrows 2011). In the case of *S. flagellum*, the conflicting drives may be to escape or to engage in one of several defensive behaviours, with the displacement behaviour being a feeding response (at least the initial stage thereof).

This work has a number of methodological shortcomings, which means that some results are preliminary and require further investigation. Being a field study, temperature and other physical variables (e.g. light level) were not able to be controlled yet are known to influence defensive behaviour in snakes (e.g. Keogh and De Serto 1994). For example, it is likely that the low (winter) temperatures inhibited a much larger percentage of snakes from initiating escape during observation and handling. Among individuals, there was also variation in the level of satiation, reproductive state (some females were gravid), and previous exposure to predators. A significant number of snakes were part of small aggregations of conspecifics. Potentially, these factors may all have influenced the behavioural responses of individual snakes (e.g. Brown and Shine 2004). The observer's interaction with the snakes varied with the circumstances of their discovery and was unlikely to resemble the manner in which a (non-human) predator would approach and then interact with a snake. The context of encounters also may have predisposed snakes to exhibiting certain defensive behaviours in preference to others. For example, snakes encountered beneath ground cover during the day may not necessarily display the same defensive response when encountered at night while they are active and away from cover. In a study of defensive behaviour in the Eastern Brown Snake *Pseudonaja textilis*, a large diurnal elapid, it was found that observer appearance and approach, time of day and season all had an influence on the type of response exhibited by snakes in the field (Whitaker and Shine 1999). A laboratory study of the defensive behaviours of *S. flagellum*, similar to Llewelyn *et al.* (2010) or Whitaker *et al.* (2000), would be useful in identifying those factors that influence the behaviours exhibited by individual snakes, and may validate, or otherwise, some of the results of this work.

The effects of human envenomation from small elapids has received little attention in the literature (Couper and Covacevich 2011). The effects of the bites of the two *Suta* species described above were very similar. Four independent accounts described to me of the symptoms experienced following bites from adult *S. flagellum* in healthy individuals (two children approximately 10–12 years old and two young adults 25–30 years old) were also very mild. By contrast, James (1979) described the immediate symptoms of an (adult?) *S. flagellum* bite to his finger that resulted in his being 'slightly dizzy', then vomiting, with swelling of both the hand and finger occurring some time later and slight soreness of the arm and hand persisting for a couple of days. Jenkins and Bartell (1980: 239) stated that *S. dwyeri* (as *Unechis gouldii*) 'is capable of delivering quite a painful bite' but no further details are provided. Clancy (2014) experienced slightly blurred vision, nausea and vomiting along with localised swelling and intense localised burning pain after a bite from a large Mitchell's Short-tailed Snake *S. nigriceps*. Anthony's (1998) reaction to the bite of a Curl Snake *Suta suta* involved an itching sensation (urticaria) that spread from the bite site to the entire body within 40 minutes and subsided after 90 minutes. A delayed allergic reaction, similar to that which I experienced with both bites, was reported following two separate instances of bites from the Eastern Small-eyed

Snake *Cryptophis nigrescens* (Bridge 1979, p. 18): 'After a couple of days the swelling subsided, but amazingly, seven and then fourteen days after the bite, his hand swelled up for several days again'; the reaction to a bite in a second person is described as being 'exactly the same'. Couper and Covacevich (2011) reported two cases of envenomation by the Black-striped Snake *Cryptophis nigrostriatus*, the more serious of the two resulting from three bites to the left hand which produced stomach cramps and an 'arthritis-like' stiffness around the bite site. Blomberg (1997) described mild, localised symptoms including redness, swelling and soreness of the bite site and stiffness of the joint after receiving a bite on the finger from an adult Ornamental Snake *Denisonia maculata* and applying a constrictive bandage. Ormsby (1950) described symptoms of a bite from an adult female Marsh Snake *Hemiaspis signata*; these were generally similar to those described in this work, though they were milder and most had subsided by the next day with no recurrence. While there are many variables to consider when assessing the severity of symptoms of snakebite in humans (such as the size and condition of both the snake and the human), collectively these accounts, involving species that are typically regarded as 'harmless', show that, in some circumstances, serious symptoms can develop in individuals.

Suta flagellum never strikes when approached; however, given the opportunity, these snakes readily bite when handled, particularly when objects are placed close to their heads. The lack of a defensive strike in *S. flagellum* means that bites do not occur at a significant distance from the snake but rather from direct contact (or nearly so) with the snake's head, as when handling. The fact that only one bite (the result of careless handling) occurred from handling more than 550 live *S. flagellum* indicates that, when care is exercised, the chance of being bitten by this species is very small. Of course it follows that if the species is not handled at all during an encounter then the chance of being bitten is negligible. *Suta flagellum* cannot be regarded as a 'dangerous' species *per se* because it is not active by day when it would be most likely to have encounters with humans, it does not possess a defensive strike, and consequently bites occur only from direct contact with the snake (i.e. handling), and biting is infrequently employed as an initial defensive response. Most bites from *S. flagellum* reported here have resulted in relatively mild symptoms, but the sample size (six) is too small to make generalisations, therefore bites from individuals of this species (of any size) should be treated with caution.

I concur with Clancy (2014) for the need to exercise caution when handling *Suta* specimens, particularly large adults, because: (i) the amount of venom injected by snakes can determine the severity of the symptoms (Mirtschin *et al.* 2017); (ii) venom yield is known to generally increase with the size of the snake (Greer 1997); (iii) *Suta* venom has not been the subject of detailed toxicological studies and may contain novel mixtures of neurotoxins and myotoxins (as well pro and anti-coagulants) similar to those occurring in dangerously venomous elapids (see Jackson *et al.* 2013), though in much smaller quantities; (iv) some *Suta* species will readily attempt to bite when handled ; and (v) the human response to envenomation as determined by age, health status, immune response, knowledge of and willingness to apply first aid and seek medical attention is highly variable.

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Sixty-eight years ago

EFFECTS OF TIGER SNAKE BITE

By IAN WALLACE

It was a warm March afternoon … It so happened that the first snake I picked up, a Tiger Snake, was particularly lively … it made a quick movement upwards, and in a flash had touched my thumb, disproving the theory that a snake is harmless while held by the tail.

In a matter of about two minutes … my heart began to beat heavily … I was held under observation for twenty-four hours [at the Royal Melbourne Hospital] before being discharged, and during that time my hand became very swollen … in my opinion the swelling was not due to infection but inflammation. The latter is, apparently, common with many snake bites, especially those of the smaller Whip Snakes (*Denisonia* spp.).

From *The Victorian Naturalist* **70**, pp. 227–228, April 8, 1954

The curious life of krill: A conservation story from the bottom of the world

Stephen Nicol

Publisher: *Island Press, Washington, USA, 2018. 194 pages, hardback. Maps, diagrams, photographs. ISBN: 978-1-61091-3. RRP $58.*

For 40 years scientist Stephen Nicol has made krill his study. My closest encounter with krill was a large jar of small, indistinct whitish creatures, with black eyes, on a bench in the Marine Invertebrates Laboratory at Museum Victoria. At the time, I thought these animals didn't have much to do with the Victorian crustaceans that interested me. But the genus name of the krill that Nicol focused on in his antarctic work is enough to make you wonder what you have been missing. *Euphausia is* Greek for 'true shining light' (p. 1). Besides being 3 cms long, when live, they transmit a spectacular show of electric blue flashing light. Their glassy bodies appear to be red and green. The green comes from eating algae (p. 8) and the red is in the pigmentation spots that may expand or contract. Millions of krill can make the ocean blood red.

Nicol begins by describing his sensational encounter with krill in northern arctic waters in his youth. Krill, according to a Norwegian colleague, is an onomatopoeic word (p.7)

> 'formed to replicate the sound of millions of krill pattering on the water as they jumped clear of the surface.'

Our understanding of krill and whales is growing. Author Stephen Nicol raises the question of what happened to krill when whales and seals were nearly hunted to extinction by the 1900s. With no whales to feed on them, did krill populations explode? The mainstream media has revealed in recent years that there is not much iron in Antarctic waters, so one can speculate that krill numbers might not have increased with fewer predators, but declined. However, whale poo contains a lot of iron.

Nicol writes of the 'whale poo hypothesis' (p. 98) saying 'my initial scepticism has been overturned' (p. 100) and details the research which shows iron concentrations in whale faeces were at least 10 million times the background level in sea water. Krill, being long-lived swimmers, keep the iron in the upper surface of the ocean from year to year as a 'buoyant reservoir of iron' (p. 99). Phytoplankton contain iron, an essential ingredient for photosynthesis. Krill feed on the phytoplankton and accumulate the iron. Whales then feed on the krill, releasing the iron in their faeces. Krill also release iron in their faeces. Phytoplankton can then take up any bio-available iron released by the whales and krill.

With only 194 pages, this book is small but, inside its covers, you will find the essence of Nicol's work: on how krill give off a light show; on the taste of it in fish fingers; or on how krill fare in laboratory conditions in Tasmania.

Chapter 7 'Conventional Approaches' is devoted to the author's work on the Australian delegation to the international commission or Commission of Conservation of Antarctic Marine Living Resources (CCAMLR, pronounced 'camel-are') (p. 128), which will aid your appreciation of the difficulties of negotiating issues of marine ecology and commercial fishing. In this part of the book, if long meetings are not your cup of tea, you might think your attention will wane, but not with Nicol. Thirty years of attending CCAMLR meetings has given Nicol a judicious and humorous insight, that helps his readers to appreciate what has been gained by negotiators who have not achieved the fame of footballers but whose consummate skill could merit a television series like *Yes Minister* or *The Thick of It*. I was astonished by Nicol's account of cold war rivalry between the USA and USSR, in which he describes how the USA placed a station right on the south pole so it could be situated in every other nation's wedge that 'converges at the bottom of the world' (p. 130). I was moved to consult my *Compact Peters Atlas of the World* and, sure enough, it was marked. The author explains that, when the USSR moved to place stations on the Norwegian and Australian

territory, negotiators stepped in to defuse this issue.

The best available scientific evidence is given for the Murray–Darling Basin legislation and the Environment Protection and Biodiversity Act of 1999. Their wording is in line with the best outcome, but the legislation fails to function because the federal government does not enforce it. With CCAMLR, which has 26 member nations, the science does count. Up-to-date scientific research informs its annual meeting; It acts accordingly and plans future scientific programs.

I am in awe of Nicol's depth of knowledge, his history of the numerous acronyms and the simple way he explains the science and the legalities. A living krill might be a flashing blue light show with a genome longer than our own, but. thanks to Nicol, we can now learn about and marvel at the achievement of a 26-member organisation which set about revealing Krill's mysterious life and function, specifically to protect this keystone species, and has stayed on task so far.

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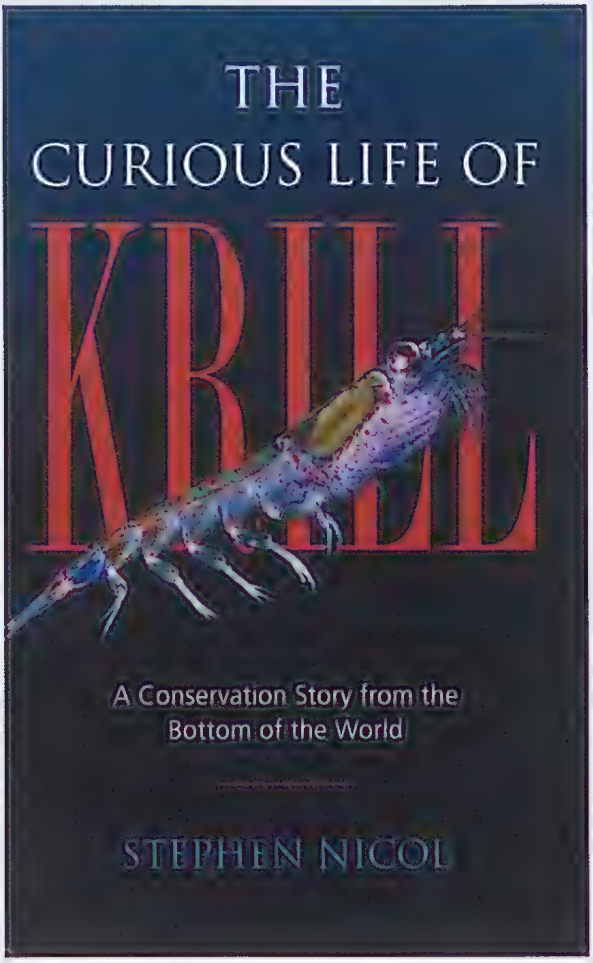

2021 Australian Natural History Medallion: Peter Latz

The 2021 Australian Natural History Medallion was awarded to Peter Latz, and the Aboriginal botanists of central Australia. They were nominated by the Alice Springs Field Naturalists Club (ASFNC).

Peter Latz is a visionary ethnobotanist. For 55 years, he worked with the Eastern and Western Arrernte, Alyawarr, Anmatjere, Pintupi/ Luritja, Pitjantjatjara/ Yankunytjatjara, and Warlpiri people to organise and share their cultural and scientific knowledge of central Australian plants. In many areas of Australia knowledge of this type has been lost; it has been preserved in the Red Centre as a result of this lifelong collaboration. Peter was born in the Arrernte settlement of Ntaria (Hermannsburg). He was raised by an Aboriginal housemaid, and every weekend explored the bush with Arrernte children of the same age. From them, Peter learned how to live off the land and 'eat everything that moved.' This early sharing of knowledge shaped his career as Australia's foremost non-Aboriginal authority on desert plants.

He began his working life learning bush skills, as a stockman, road train driver, buffalo wrangler, snake handler, and then stock inspector of buffaloes around Darwin. His supervisor saw Peter reading zoology journals and told him that he could be paid for studying animals. Peter obtained a Bachelors degree in Zoology and Botany from Adelaide University. In 1978 he held a visiting fellowship at ANU to study Aboriginal pre-contact use of the land. This was followed by a Masters degree at New England University on the Aboriginal use of plants. By the time Peter submitted his M.Sc. thesis, in 1982, he was leading the emerging national interest in Aboriginal uses of native species.

He has described many plants new to Western science, and other botanists have named at least 10 plants after him, including: a desert tree *Acacia latzii*; a tropical herb *Sauropus latzii*; and four species of grass —*Aristida latzii*, *Sporobolus latzii*, *Panicum latzii*, and *Triodia latzii*.

In 1988 Peter worked with local Aboriginal experts to promote a much larger variety of bush potato with commercial value in arid lands, *Ipomoea polpha* subsp. *latzii*. The species may live 50 years and occurs in a single location, 200 km NE of Alice Springs.

Peter conducted the first botanical survey of the Wessel Islands (NT), where he described several new plant species for the NT. He surveyed Kings Canyon to determine if it should be a national park, during which time he identified plants endemic to the area, as well as plants that occur only here and in Tasmania, coexisting with local but more widely occurring species.

Peter documented his knowledge in the scientific literature and also produced the landmark text *Bushfires and Bushtucker* (1995, republished 2018). For the first time, western scientific and Aboriginal knowledge of central Australian bush foods was brought together in a comprehensive textbook.

Before the publication of this book, many of these plants had been poorly or incorrectly identified, and there was little information on the finer points of plant utilisation. To identify gaps in his knowledge, Peter attempted to live off the land. When he encountered difficulties, he consulted with dozens of Aboriginal experts to obtain information that had never been recorded.

Often, the value of any scientific work is measured by its 'ripple effect' in stimulating further studies; *Bushfires and Bushtucker* certainly made waves! It is cited in a wide range of closely-related scholarship including: detailed studies of Aboriginal methods for using native species; identifying active compounds with medicinal properties in *Eremophila* (emu or native fuchsia bushes); and land management focused on local plants. It stimulated research into more distant topics, such as describing new species of *Acacia* (wattles) in central and in northern savanna Australia. And the book

Peter Latz is presented with the Medallion by Barbara Gilfedder, President of Alice Springs Field Naturalists Club.

encouraged research activities looking into arid zone fire and its effects on flora, and in the use and management of fire by local peoples.

Peter's other publications include an abridged version of *Bushfires and Bushtucker*, titled *Pocket Bushtucker; and The Flaming Desert* (2007), which presents his assessment of the prehistory and current ecology of central Australia, focusing on Aboriginal use of fire. Growing up in Ntaria, Peter was deeply impressed by a Western Aranda 'man of high degree', Moses Tjakalbota Uriaiakuraia. Peter drew on his experience, archives and the subject's own account, to publish the remarkable story of *Blind Moses* (2014).

In 1970, Peter was hired as a botanist for the Northern Territory Herbarium, a position he held for 40 years. In that role, he spent his career collecting and describing many rare plants, for inclusion in the Herbarium's collection. He worked with Aboriginal botanists to identify—in nine languages—the names of these plants. He regularly identified plants for ecological consultants, taught Aboriginal Rangers through the Central Land Council and advised on many conservation issues. He is now retired.

Peter continually volunteers his time for every environmental organisation in the region: as a speaker on the risk of weeds, and a leader of bush walks for the ASFNC; as a trainer for Alice Springs Landcare, particularly on weed removal in the Todd River; as an adviser to Olive Pink Botanic Garden on native plant behaviour and care; and to Arid Lands Environment Centre on land management practices; and as a teacher of the next generation of Aboriginal botanists. He is particularly concerned about the ongoing impact of Buffel Grass, and the growing risks of other weeds. On his own block, Peter has demonstrated how to restore Buffel-infested land to a native state. He also adopted a riparian ecosystem, fenced it from cattle, and over many years removed weeds to restore its native plant diversity. It has since become a destination for Field Naturalist Club excursions, to view the diversity in local native plant communities.

Peter Latz stands out for his extensive, lifelong work which has become a bridge between Aboriginal and European botanical and environmental cultures. He continues to contribute and volunteer in various capacities, including advising on weed removal, native plant care and arid land management. His own land is a working example of the best kind of management, and a favourite destination for Field Naturalist excursions.

The Medallion was presented to Peter by Barbara Gilfedder, President of ASFNC, on Sunday 31 October, 2021, at Olive Pink Botanic Garden, Alice Springs.

Maxwell Campbell
Secretary, ANHM Committee,
Field Naturalists Club of Victoria,
PO Box 13, Blackburn,
Victoria 3130.
With assistance, gratefully received, from members of ASFNC

Australian Natural History Medallion Trust Fund

During 2021, donations to the ANHM Trust Fund were gratefully received from the following:

	$		$
Jorg Metz	10.00	Tasmanian FNC Inc	250.00
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Rodger Elliott	10.00	Murray Littlejohn	50.00
David Munro	15.00	Rochelle Jardine	10.00
Julia Davis	10.00	Jae Bershenesh	50.00
Rob Wallis	25.00		

If you would like to contribute to this fund, which supports the Australian Natural History Medallion, donations should be sent to: The Treasurer, Field Naturalists Club of Victoria, PO Box 13, Blackburn, Victoria 3130. Cheques should be made payable to the 'Australian Natural History Medallion Trust Fund'.

The medallion is awarded annually to a person who is considered to have made the most significant contribution to the understanding of Australian natural history.

Maxwell Campbell
Secretary, ANHM Committee,
Field Naturalists Club of Victoria,
PO Box 13, Blackburn,
Victoria 3130.

Guidelines for authors – *The Victorian Naturalist*

April 2022

The Victorian Naturalist welcomes the submission of papers presenting original and significant research. When preparing a paper for publication, please follow the journal style as closely as possible.

Submission of a manuscript will be taken to mean that the material has not been published, nor is being considered for publication elsewhere, and that all authors agree to its submission.

Authors may submit material in the form of Research Reports, Contributions, Naturalist Notes, Letters to the Editor and Book Reviews. All Research Reports and Contributions are peer reviewed by external referees. A ***Research Report*** records the results of a structured study that employs methods and analyses designed to answer a question. It is written in the third person, and in a form that includes an abstract, introduction, methods, results and discussion. A ***Contribution*** answers a question through research, which is not necessarily new, e.g. it could be a literature review used to provide the answer, or make a comparison. The scope of a contribution is broad, in order to encourage material on a wide range of topics and in a range of styles. This allows inclusion of material that makes a contribution to our knowledge of natural history but for which the traditional format of scientific papers is not appropriate. ***Symposia papers*** are the published form of papers presented at FNCV symposia and will be reviewed inhouse. ***Naturalist Notes*** are generally short, personal accounts of observations made in the field by anyone with an interest in natural history. These Notes also may include reports on excursions and talks, or comment on matters relating to natural history. ***Letters to the Editor*** must be no longer than 500 words. ***Book Reviews*** are usually commissioned, but the editors also welcome enquiries from potential reviewers.

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Manuscripts should be submitted by email, or by post, on a USB. Documents should be in Microsoft Word. Original artwork can be withheld by the author until acceptance of the manuscript. Manuscripts should be typed, double spaced with wide margins and pages numbered. Please indicate the telephone number and email address (if available) of the author who is to receive correspondence. Submission of manuscripts should be accompanied by a covering letter.

The ***title*** should be concise, interesting and informative and not stated as a question.

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Abbreviations

The following abbreviations should be used in the manuscript where appropriate (italicised as indicated): *et al.*; unpubl. data; pers. obs.; pers. comm. (**each followed by a relevant date**); 'subsp.' for subspecies.

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The International System of Units (SI units) should be used for exact measurement of physical quantities.

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All nucleotide sequence data and alignments should be submitted to an appropriate public database, such as Genbank or EMBL. The accession numbers for all sequences must be cited in the article.

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For further information on style, write to the editors, or consult the Australian Government Style Manual online at <https://www.stylemanual.gov.au>.

Authors are advised to note the layout of headings, tables and illustrations as given in recent issues of the journal. A full stop is followed by a **single space; single quotation marks** are used throughout.

In all papers, first reference to a species should use both the common name and binomial. This journal uses capitalised common names for species, followed by the binomial in italics without brackets, e.g. Kangaroo Grass *Themeda triandra*. However, where many species are mentioned, a list (an appendix at the end), with both common and binomial names, may be preferred. Lists must be in taxonomic order using the order in which they appear in the references recommended below.

References to printed sources
References in the text should cite author and year, e.g. Brown (1990), (Brown 1990), (Brown 1990, 1991), (Brown 1995 unpubl.), (Brown and Green 1990), (Brown and Green 1990; Blue 1990; Red 1990). If there are more than two authors for a paper use (Brown *et al.* 1990). All references mentioned in the text should be included, in alphabetic order, at the end of the text under **References** (see examples below). The use of unpublished data is accepted only if the data are available on request for viewing. Pers. obs. and pers. comm. should not be included in the list of references. **Journal titles should be given in full.**

Leigh J, Boden R and Briggs J (1984) *Extinct and Endangered Plants of Australia*. (Macmillan: South Melbourne).

Lunney D (1995) Bush Rat. In *The Mammals of Australia*, pp. 651–653. Ed R Strahan. (Australian Museum/Reed New Holland: Sydney).

Phillips A and Watson R (1991) *Xanthorrhoea*: consequences of 'horticultural fashion'. *The Victorian Naturalist* **108**, 130–133.

Smith AB (1995) Flowering plants in north-eastern Victoria. (Unpublished PhD thesis, The University of Melbourne).

Wolf L and Chippendale GM (1981) The natural distribution of *Eucalyptus* in Australia. Australian National Parks and Wildlife Service, Special Publications No 6, Canberra.

References to websites
Reference within the text to a website, should be in the form **('Website name' 'year')**. All references mentioned in the text should be included, in alphabetic order, at the end of the text, complete with the date website was accessed, e.g.

BoM (2014) Climate data online. (Bureau of Meteorology: Melbourne). <http://www.bom.gov.au> [accessed 14 January 2014].

Where an author can be ascribed to the webpage, details should be given, e.g.

Wikipedia contributors (2020a) *Schinus terebinthfolia*. In *Wikipedia, The Free Encyclopedia* <https://en.wikipedia.org/w/index.php?title=Schinus_terebinthifolia&oldid=985239010> [accessed 12 October 2020].

References to newspapers
Reference within the text to a newspaper article, should be in the form ('Anon' or 'Author name', if given, year). The reference must be inlcuded in the list of references in the following form:

Anon *Central Queensland Herald* (*The*) 30 April 1931, p. 7.

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Cite references used for taxonomic names. **Checking species names is the responsibility of authors.** The books and websites that we use as references for articles in *The Victorian Naturalist* are listed below. **Authors should refer to the source used for species names in their manuscripts.** In every case, the latest edition should be used.

Mammals—Menkhorst PW and Knight F (2011) *A Field Guide to the Mammals of Australia*. 3rd edn. (Oxford University Press: South Melbourne).

Reptiles and Amphibians—Cogger H (2018) *Reptiles and Amphibians of Australia*. Updated 7th edn. (CSIRO: Collingwood).

Insects and Marine Creatures—ABRS: <http://www.environment.gov.au/biodiversity/abrs/online-resources/fauna/index.html>.

Birds—Menkhorst P *et. al* (2019) *The Australian Bird Guide*, Revd edn. (CSIRO: Clayton South).

Plants—VicFlora (2022). Flora of Victoria, Royal Botanic Gardens Melbourne, <https://vicflora.rbg.vic.gov.au>. [accessed (insert date: day, month, year)].

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